

What is claimed is:

1. A semiconductor device, comprising:  
a source electrode;  
a drain electrode;  
5 a channel coupled to the source electrode and the drain electrode and  
comprised of a ternary compound containing zinc, tin and oxygen; and  
a gate electrode configured to permit application of an electric field to the  
channel.

10 2. The semiconductor device of claim 1, where at least a portion of the  
channel is formed from a zinc-tin oxide compound having the following  
stoichiometry:  $Zn_xSn_yO_z$ , where x, y and z have positive non-zero values.

15 3. The semiconductor device of claim 2, where the zinc-tin oxide  
compound has the following stoichiometry:  $ZnSnO_3$ .

4. The semiconductor device of claim 2, where the zinc-tin oxide  
compound has the following stoichiometry:  $Zn_2SnO_4$ .

20 5. The semiconductor device of claim 2, where the zinc-tin oxide  
compound has the following stoichiometry:  $(ZnO)_j(SnO_2)_{1-j}$ , where j is between  
0.05 and 0.95.

25 6. The semiconductor device of claim 2, where the zinc-tin oxide  
compound is substantially amorphous.

7. The semiconductor device of claim 2, where one or more of the  
source, drain, and gate electrodes is fabricated so as to be at least partially  
transparent.

8. The semiconductor device of claim 2, where the channel further includes phase-segregated ZnO.

9. The semiconductor device of claim 2, where the channel further  
5 includes phase-segregated SnO<sub>2</sub>.

10. The semiconductor device of claim 1, where one or more of the source, drain, and gate electrodes is fabricated so as to be at least partially transparent.

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11. The semiconductor device of claim 1, where the channel is deposited using an RF sputtering process.

12. The semiconductor device of claim 1, where the source electrode  
15 and the drain electrode are formed by depositing an indium-tin oxide material and patterning the indium-tin oxide material so that the source electrode and drain electrode are physically separate from one another.

13. The semiconductor device of claim 1, where the gate electrode is  
20 physically separated from the channel by a dielectric material.

14. The semiconductor device of claim 1, where the dielectric material is an aluminum-titanium oxide material.

15. The semiconductor device of claim 14, where the dielectric material includes:

a first outer layer immediately adjacent to and in contact with the channel layer;

5 a second outer layer immediately adjacent to and in contact with the gate electrode, where the first and second outer layers are each formed from  $\text{Al}_2\text{O}_3$ ; and

alternating interior layers of  $\text{AlO}_x$  and  $\text{TiO}_y$  between the first and second outer layers, where x and y are positive nonzero values.

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16. A three-port semiconductor device, comprising:

a source electrode;

a drain electrode;

a gate electrode; and

15 means for providing a channel disposed between the source electrode and drain electrode, the means for providing a channel configured to permit movement of electric charge therethrough between the source electrode and the gate electrode in response to a voltage applied at the gate electrode, the means for providing a channel formed at least in part from a ternary compound  
20 containing zinc, tin and oxygen.

17. The semiconductor device of claim 16, where the means for providing a channel includes means for providing a semiconductor formed from a zinc-tin oxide compound having the following stoichiometry:  $\text{Zn}_x\text{Sn}_y\text{O}_z$ , where x, y  
25 and z have positive non-zero values.

18. The semiconductor device of claim 17, where the zinc-tin oxide compound has the following stoichiometry:  $\text{ZnSnO}_3$ .

30 19. The semiconductor device of claim 17, where the zinc-tin oxide compound has the following stoichiometry:  $\text{Zn}_2\text{SnO}_4$ .

20. The semiconductor device of claim 17, where the means for providing a semiconductor includes a compound that has the following stoichiometry:  $(\text{ZnO})_j(\text{SnO}_2)_{1-j}$ , where  $j$  is between 0.05 and 0.95.

5 21. The semiconductor device of claim 17, where the means for providing a semiconductor is substantially amorphous.

22. The semiconductor device of claim 17, where one or more of the source, drain, and gate electrodes is fabricated so as to be at least partially  
10 transparent.

23. The semiconductor device of claim 16, where the source electrode and the drain electrode are formed by depositing an indium-tin oxide material and patterning the indium-tin oxide material so that the source electrode and the drain  
15 electrode are physically separate from one another.

24. The semiconductor device of claim 16, further comprising means for providing a dielectric disposed between and physically separating the gate electrode from the means for providing a channel.  
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25. A thin-film transistor, comprising:

a gate electrode;

a channel layer formed from a zinc-tin oxide material;

5 a dielectric material disposed between and separating the gate electrode and the channel layer; and

first and second electrodes spaced from each other and disposed adjacent the channel layer on a side of the channel layer opposite the dielectric material, such that the channel layer is disposed between and electrically separates the first and second electrodes.

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26. The thin-film transistor of claim 25, where the thin-film transistor is configured so that the ability of the channel layer to convey electric charge between the first and second electrodes in response to a potential difference applied across the first and second electrodes is dependent upon a gate voltage applied at the gate electrode.

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27. The thin-film transistor of claim 25, where at least a portion of the channel layer is formed from a zinc-tin oxide compound having the following stoichiometry:  $Zn_xSn_yO_z$ , where x, y and z have positive non-zero values.

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28. The thin-film transistor of claim 27, where the zinc-tin oxide compound has the following stoichiometry:  $ZnSnO_3$ .

29. The thin-film transistor of claim 27, where the zinc-tin oxide compound has the following stoichiometry:  $Zn_2SnO_4$ .

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30. The thin-film transistor of claim 27, where the zinc-tin oxide compound has the following stoichiometry:  $(ZnO)_j(SnO_2)_{1-j}$ , where j is between 0.05 and 0.95.

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31. The thin-film transistor of claim 27, where the zinc-tin oxide compound is substantially amorphous.

5 32. The thin-film transistor of claim 27, where one or more of the source, drain, and gate electrodes is fabricated so as to be at least partially transparent.

10 33. The thin-film transistor of claim 27, where the channel layer further includes phase-segregated ZnO.

34. The thin-film transistor of claim 27, where the channel layer further includes phase-segregated SnO<sub>2</sub>.

15 35. The thin-film transistor of claim 25, where one or more of the source, drain, and gate electrodes is fabricated so as to be at least partially transparent.

20 36. The thin-film transistor of claim 25, where the channel layer is deposited using an RF sputtering process.

37. The thin-film transistor of claim 25, where the first and second electrodes are formed by depositing an indium-tin oxide material and patterning the indium-tin oxide material so that the first and second electrodes are physically separate from one another.

25 38. The thin-film transistor of claim 25, where the dielectric material is an aluminum-titanium oxide material.

39. The thin-film transistor of claim 38, where the dielectric material includes:

a first outer layer immediately adjacent to and in contact with the channel layer;

5 a second outer layer immediately adjacent to and in contact with the gate electrode, where the first and second outer layers are each formed from  $\text{Al}_2\text{O}_3$ ; and

alternating interior layers of  $\text{AlO}_x$  and  $\text{TiO}_y$  between the first and second outer layers, where x and y are positive nonzero values.

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40. A method of controlling an active matrix display, comprising:

providing a three-port semiconductor device, where the semiconductor device includes a zinc-tin oxide channel layer configured to permit charge transport between a source electrode and a drain electrode of the semiconductor device based upon a gate voltage applied to a gate electrode of the semiconductor device; and

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selectively controlling activation and deactivation of a pixel of the active matrix display by selectively controlling the gate voltage.

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41. The method of claim 40, where selectively controlling activation and deactivation of the pixel includes turning on the pixel in response to an increase in current flowing between the source electrode and the drain electrode through the zinc-tin oxide material.

42. The method of claim 41, where selectively controlling activation and deactivation of the pixel includes increasing voltage at the gate electrode so as to enable the channel layer and thereby produce the increase in current.

5 43. A semiconductor-based switching method, comprising:  
selectively switching a semiconductor device having a zinc-tin oxide charge-transport channel layer between an activated state and a deactivated state, where placing the device into the activated state includes:

causing voltage at a gate electrode of the semiconductor device to  
10 be at or above a turn-on voltage, to thereby increase the ability of the charge-transport channel layer of the semiconductor device to carry charge between a source electrode and a drain electrode of the semiconductor device,

and where placing the device into the deactivated state includes causing  
15 voltage at the gate electrode to be at a turn-off voltage, to thereby inhibit the ability of the charge-transport channel layer to carry charge between the source electrode and the drain electrode.

44. A method of making a thin-film transistor, comprising:  
20 providing a substrate;  
depositing a gate electrode on the substrate;  
depositing a dielectric material on the gate electrode;  
depositing a channel layer on the dielectric material, such that the dielectric material is disposed between the channel layer and the gate electrode,  
25 where the channel layer is at least partially formed from a ternary compound containing zinc, tin and oxygen; and

forming first and second electrodes adjacent the channel layer so that the first and second electrodes contact the channel layer but are physically separate from each other, and so that the channel layer separates the first and second  
30 electrodes from the dielectric layer.



45. A display, comprising:

a plurality of display elements configured to operate collectively to display images, where each of the display elements includes a semiconductor device configured to control light emitted by the display element, the semiconductor device including:

a source electrode;

a drain electrode;

a channel coupled to the source electrode and the drain electrode and comprised of a ternary compound containing zinc, tin and oxygen; and

a gate electrode configured to permit application of an electric field to the channel.

46. The display of claim 45, where at least a portion of the channel of the semiconductor device is formed from a zinc-tin oxide compound having the following stoichiometry:  $Zn_xSn_yO_z$ , where x, y and z have positive non-zero values.

47. The display of claim 46, where the zinc-tin oxide compound has the following stoichiometry:  $ZnSnO_3$ .

48. The display of claim 46, where the zinc-tin oxide compound has the following stoichiometry:  $Zn_2SnO_4$ .

49. The display of claim 46, where the zinc-tin oxide compound has the following stoichiometry:  $(ZnO)_j(SnO_2)_{1-j}$ , where j is between 0.05 and 0.95.